An active loop receiving antenna for 1.8 - 4 MHz

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In locations where it is impractical to erect a conventional antenna, or where local noise is a problem, a popular alternative is to use a small receiving antenna. Some enthusiasts favour either an un-tuned or broad-band voltage-probe (or 'whip'), while others prefer an un-tuned loop, either of these then followed by a broad-band amplifier to raise the signal level to near that obtained from a conventional antenna.

A problem with broadband antennas, particularly when operated just above the broadcast band at 1.8 MHz, is that, in addition to wanted signal(s), a host of powerful, unwanted, out-of-band signals are also applied to the receiver's input. If the receiver's front-end signal handling ability (inter-modulation and pre-selectivity) is less than very good, then various undesirable effects will almost certainly occur.

If the antenna is resonated at the receiving frequency, however, the natural selectivity of the circuit will greatly attenuate the strength of out-of-band signals before they are presented to the front-end.

Apart from positioning, the whip offers little discrimination against locally generated noise, whereas a tuned loop can usually be oriented to obtain a worthwhile, and often remarkable, improvement in signal-to-noise ratio (Reference 1).

Offered here are details of a simple, tuned, balanced loop antenna for sensitive listening between about 1.75 and 4 MHz. Internally generated noise is low, thus allowing sub-microvolt signals to be heard.

Circuit

A seven-turn, 280 mm square, 'pan-cake' coil of 46 micro-Henrys is resonated by a two-gang broadcast type variable capacitor between (about) 1.75 and 4 MHz (it was found by experiment that this loop yields a measurably higher 'Q', and better sensitivity than a ferrite-rod/ loop-stick).

The frame of the capacitor is connected to chassis ground, thus forming a balanced tuned circuit which ensures that the loop is only responsive to the magnetic component of the incoming wave (simple unbalanced circuits may respond slightly to the electric component also, thus skewing the null in direction-finding applications).

For an electrically (and physically) small antenna, a substantial amount of amplification is required to raise the signal level to a value similar to that obtained from a 'full-size' one. Initial pre-amplification is provided by a balanced (or push-pull) pair of ordinary 2N5484 FETs (Figure 1).

The job of interfacing between the drains of the FETs, and the unbalanced coax line to the receiver's input, is done with a 'long-tail' pair differential amplifier (References 2 and 3).

The discrete component configuration shown is modelled upon the classic CA3028 chip (unfortunately, no longer readily available), which provides further robust RF amplification of incoming signal(s). Their collectors are coupled to the receiver's input by use of a broad-band transformer, whose bifilar wound (p)rimary provides a balanced load to the collectors of the long-tail pair. Signal is extracted via a 4-turn link (s)econdary winding.

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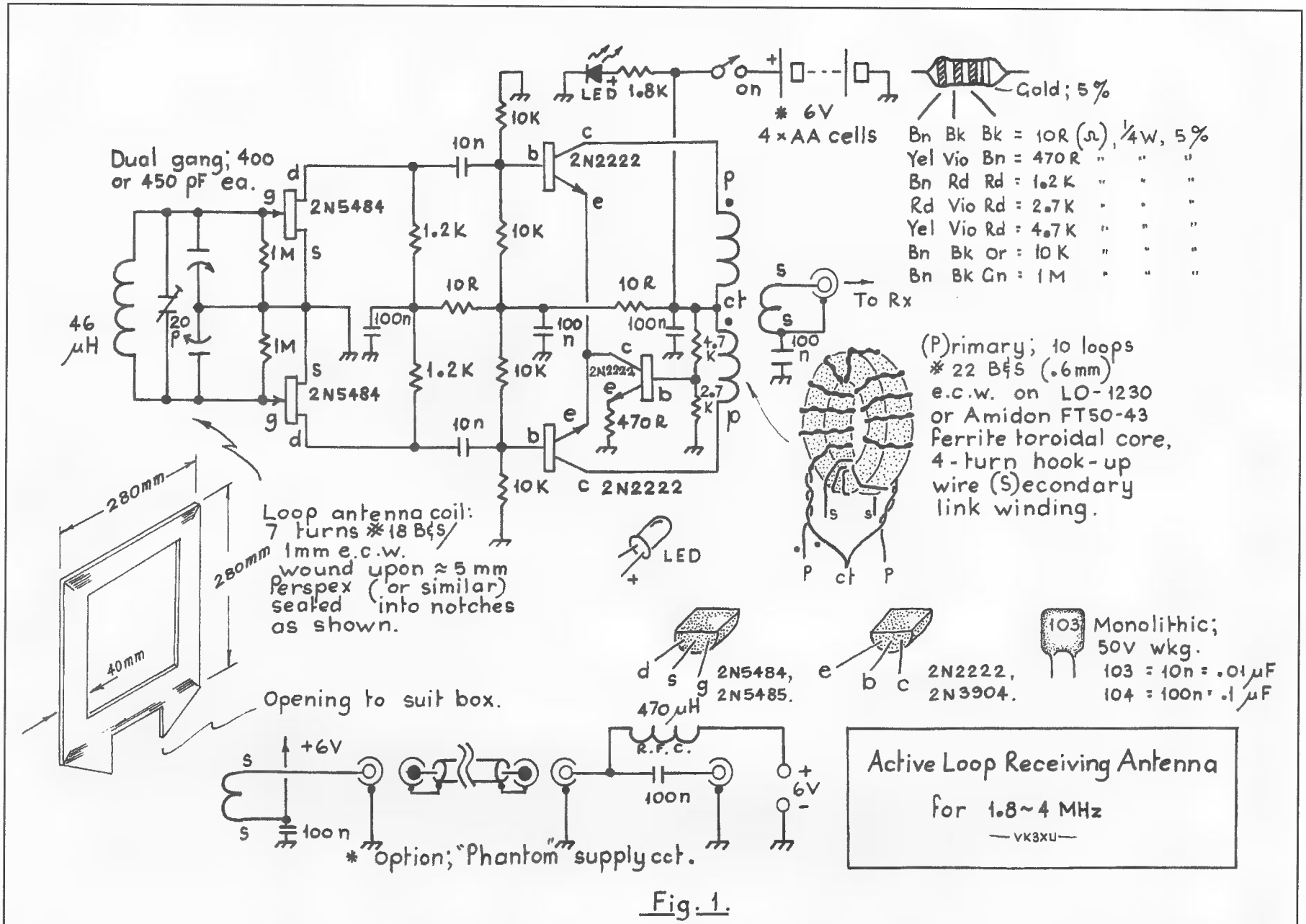

Fig. 1.

Figure 1: Schematic of the active loop receiving antenna for 1.8 - 4 MHz.

Construction

The prototype model is housed in a water-proof Jaycar ABS plastic box measuring 115 x 90 x 55 mm, P/N HB-6126.

The amplifier components are accommodated upon a 'paddyboard' (Reference 4) circuit board measuring 88 x 79 mm. A suggested layout is depicted in Figure 2 and Photo 2. Alternatively, any preferred wiring style (such as 'ugly') may be employed, provided that component leads are reasonably short, and a 'ground-plane' circuit board is used.

Use super-glue, or preferably hot-melt glue, to affix the pads/strips upon the circuit board, whereby a tiny sliver of solid glue is attached to the underside (fibre) of the pad. Melt the glue evenly with a soldering iron, then place the pad/strip in the exact spot required. If you need to move a pad, apply the iron to the copper side of the pad to soften the glue, then remove and re-position as required.

The seven-turn antenna loop coil is made with 18 B&S (1 mm) enamelled copper wire (ecw) wound upon a frame of 5 mm 'Perspex' (or similar low loss material – plywood as second best), as shown in Figure 1. The wire is wound side by side, alternated front to back, into 45-degree notches formed with a hack-saw in the frame at four places. One such notch in the upper part is pictured in Photo 3. The antenna assembly may be attached to the box in a manner similar to that illustrated in Photo 1, where a bead of hot-melt glue has been applied to both sides at the join.

The variable tuning capacitor, visible in Photo 2, is a small 400 + 400 pF dual-gang MSP part salvaged from an old Australian broadcast set. These are fairly common around the swap-meets. Or you could use a similarly ubiquitous Philips 450 + 450, or a Roblan 450 + 450 pF. It may be that your capacitor can be fitted so that the spindle emerges at the side of the box, rather than the front.

The broadband output coupling transformer may be made as follows. Take two 370 mm lengths of #22 B&S/0.6 mm ecw. Fix them, jointly, at one end in the jaws of a vice. Twist the free ends together similarly, then clamp in the chuck of a hand-drill. Whilst maintaining a tension on the pair, crank

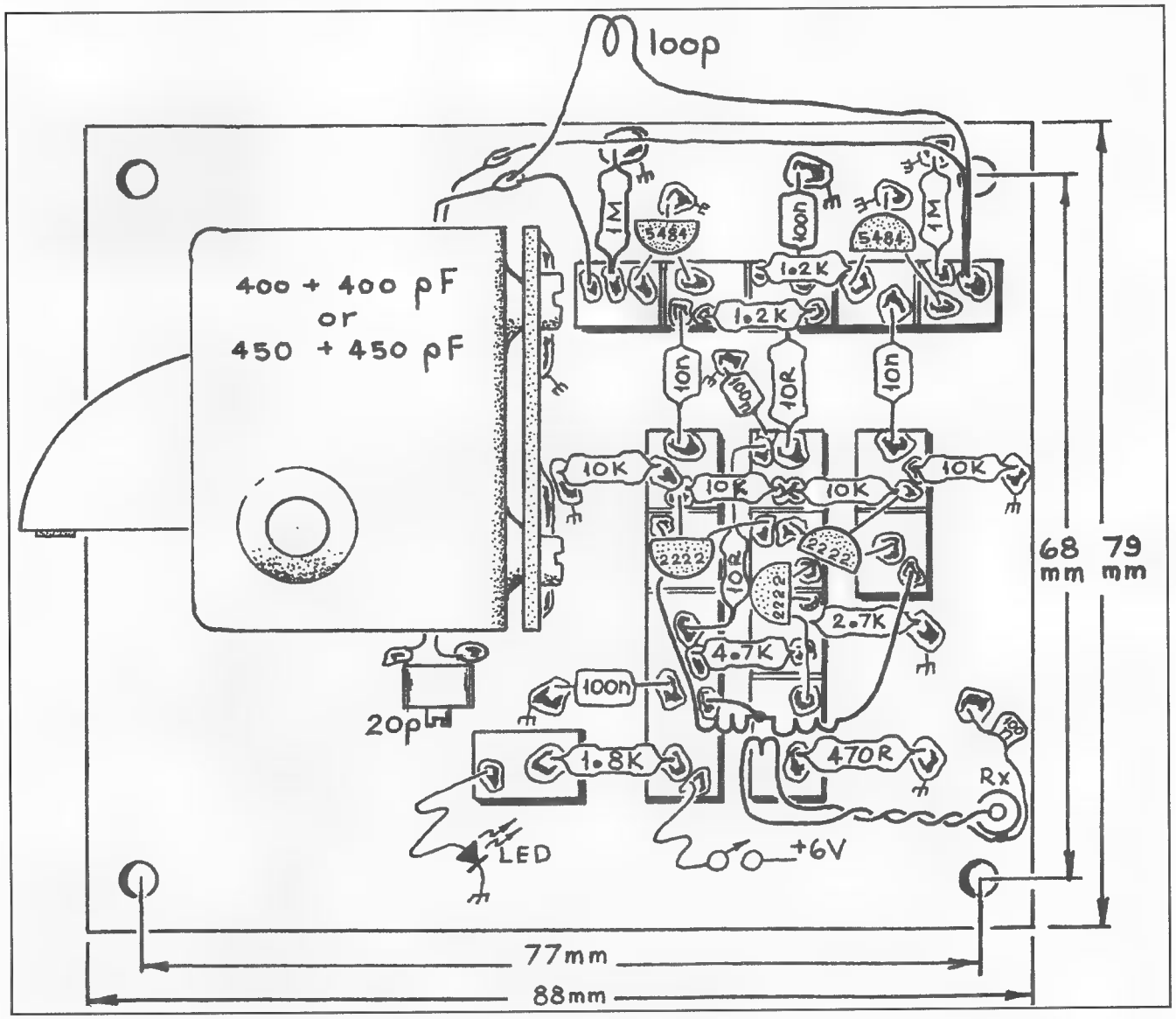

Figure 2: Suggested layout of the components on the 'paddyboard'.

the drill until you have about three twists per 10 mm. Now give the drill a firm pull to 'set' the bifilar pair. Carefully wind the pair on to a Jaycar LO-1230, or an Amidon FT50-43 toroid - about 10 loops should fit nicely, leaving a gap for the four-turn hook-up wire link (s)econdary winding.

With a multimeter set to read ohms, identify the two (p)rimary windings, and then connect the end of one to the start (dot) of the other, to form the centre tap (ct).

The 6 V battery of four AA cells may be accommodated in a holder, such as the Jaycar PH-9204. It can be attached to the lower outside surface of the box with small screws and nuts, or simply fixed there with hot-melt glue. The LED is fitted into the front panel to serve as an 'on' and battery condition indicator.

Operation

Inspect your wiring and soldering for quality and accuracy. Prove that the FETs and transistors are correctly fitted, and that your battery of AA cells is properly installed.

Connect the amplifier output to the receiver input using any reasonable length of 50 ohm coax cable. Tune the receiver to 4 MHz. Set the antenna's variable capacitor near minimum capacity. Switch on, and carefully adjust the 20 pF trimmer for a peak in noise/signals. Check that the antenna can be peaked at any frequency between 1.8 and 4 MHz. If conditions are fair to good, the set-up should sound quite lively. Any local noise/interfering signals should be reducible by careful rotation of the loop's plane.

My loop has been tested in various typical locations (some of them quite noisy) during our travels. It provides

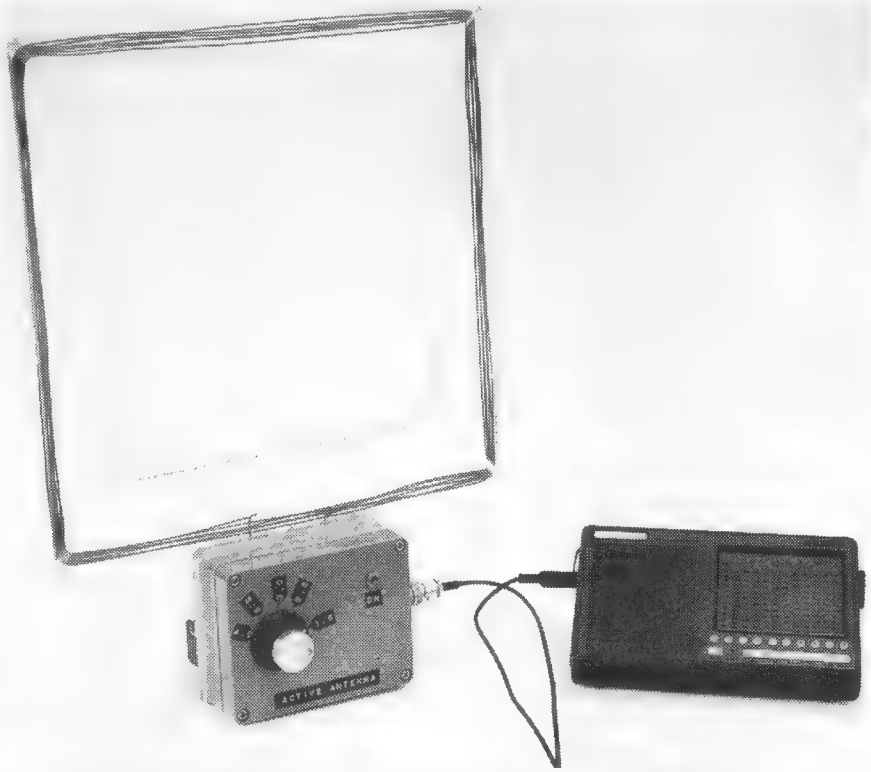

Photo 1: The active loop receiving antenna for 1.8 - 4 MHz in action.

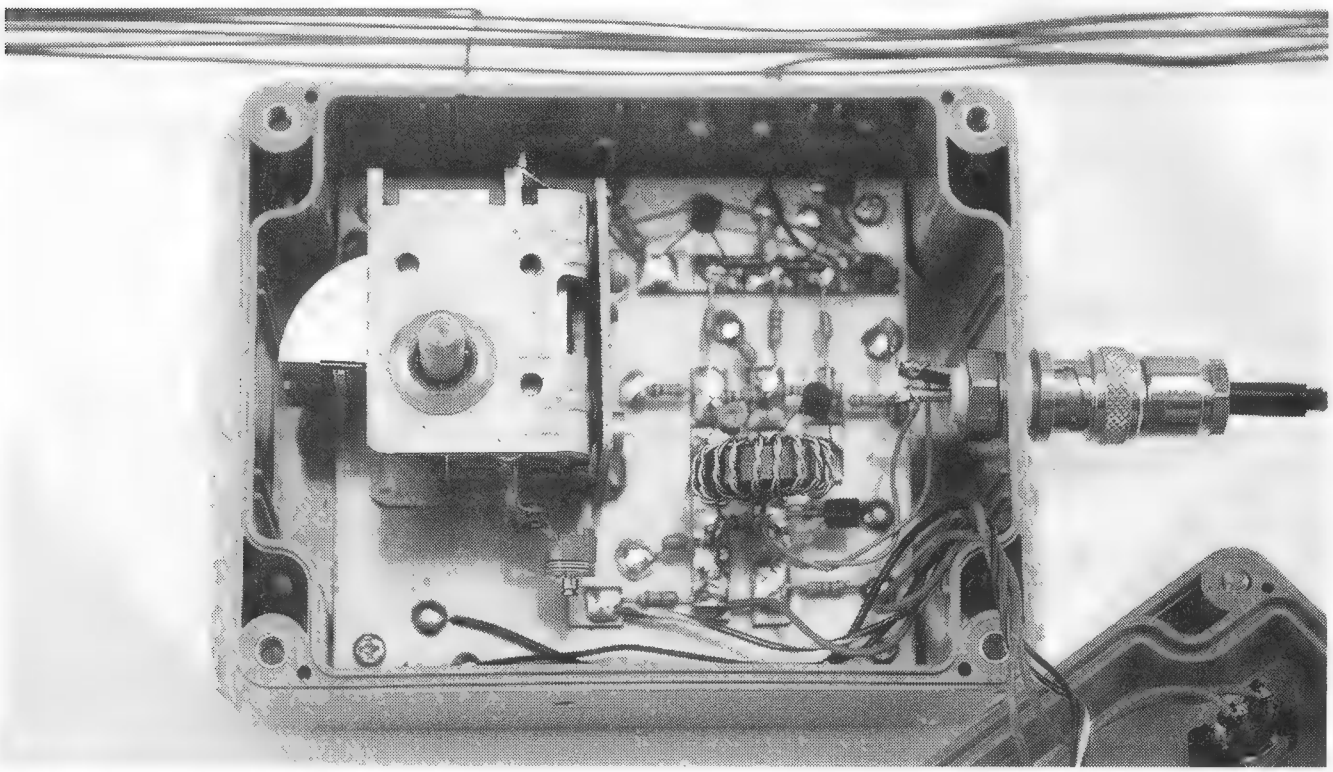

Photo 2: A view of the components mounted in the plastic box on the 'paddyboard' with the box lid removed.

(perhaps surprisingly) good performance indoors.

At a distance from electric power lines and appliances, however, a portable receiver/loop combo gives excellent results. For receivers that have a DX/local switch (such as the popular Sangean and Degen sets), it should be found that the DX position is seldom required (thus giving better strong-signal handling).

As long as a reasonable separation is maintained between a transmitting antenna and loop, no damage should be caused to the amplifier or receiver. However, an accidental transmission into the output of the device would probably damage the amplifier.

Counter-intuitively, perhaps, the null is through the axis of the loop (that is, when the loop is 'broad-side on', see Reference 1).

A suggested circuit is included in Figure 1 to provide 'phantom' power for remote operation. The loop must not be allowed to get wet. For permanent use outdoors, therefore, it is suggested that the antenna be housed inside an inverted plastic bucket, or similar contrivance.

Parts

All the ordinary components are available from our usual parts suppliers, including Altronics, Electronic World, Jaycar, Rockby and Semtronics. Sources for the ABS Box, toroidal core and variable capacitor are mentioned in **Construction** above.

You may well find (as is the case in nearby Ringwood) that off-cuts of Perspex/acrylic sheet are available from the scrap-box of your local plastic sign maker, free for the asking.

I am not in the parts business. Nevertheless, if, after earnest efforts, one or two items remain elusive, do phone me on (03) 9722 1620, or drop me a line, as it may well be that I have spares on hand.

References and Further Reading

1. "Small Loop Receiving Antennas"; Joseph Carr, *Electronics World*, November 2000.

2. *The Art of Electronics, 2nd edition*; pp 98 ~ 104, Horowitz & Hill, Cambridge University Press.

3. *Experimental Methods in RF Design*: pp 2.16 ~ 2.18 (excellent), Wes Hayward et al, ARRL.

4. "'Paddyboard' Circuit Construction - Revised", *Amateur Radio*, May 2005.

Photos by Andrew Diamond

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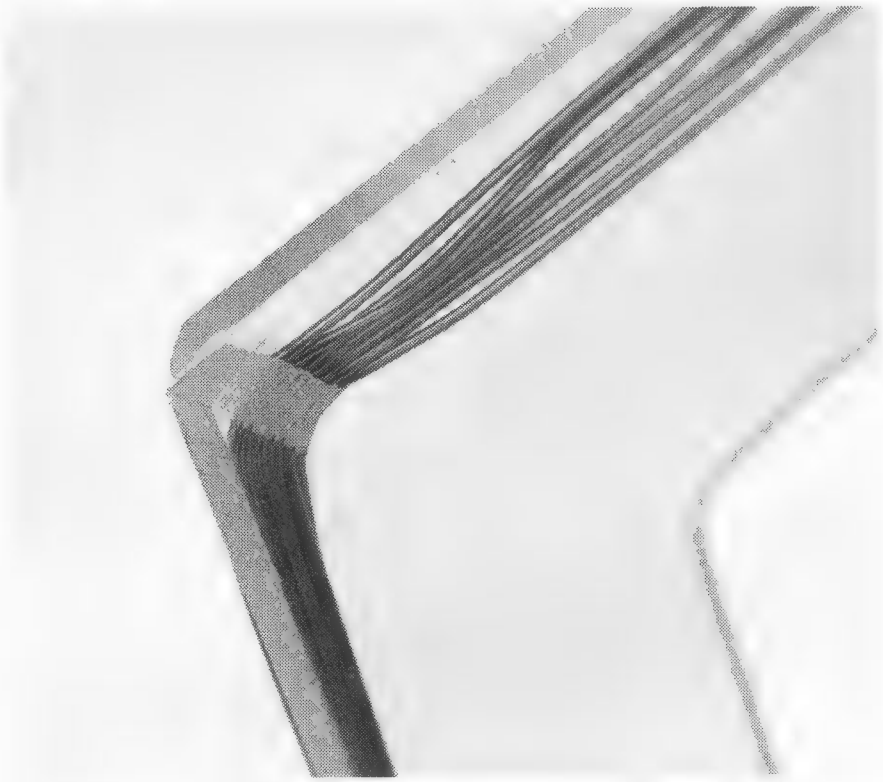

Photo 3: One corner of the loop, showing turns wound side by side in the notch.

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